Poster Presentation Charts for

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High Thermal Conductivity NARloy-Z-Diamond Composite for Advanced Rocket Engines

Objectives:

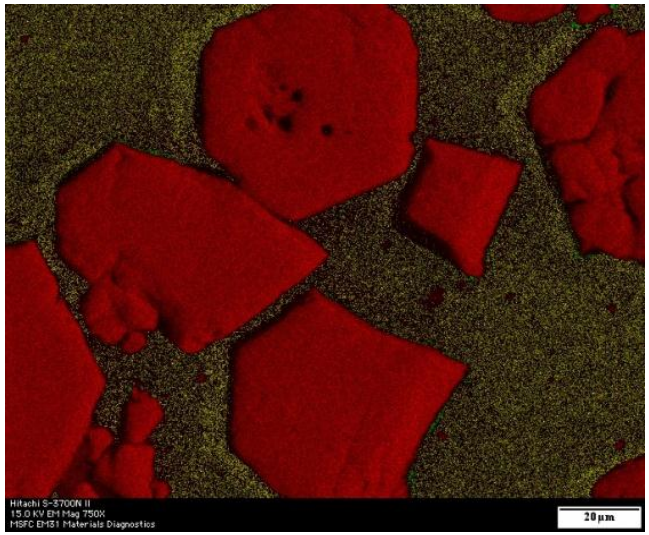
- Develop high thermal conductivity NARloy-Z-Diamond composite (NARloy-Z-D)) material for advanced rocket engines
- Develop near net shape fabrication technique for NARloy-Z-D combustion chamber liner

Technical Goals:

- Significant improvement in thermal conductivity over state of the art NARloy-Z alloy
  -- up to 2X
- Significant improvement in the performance of combustion chamber liner made from NARloy-Z-D

Target Applications:

- Combustion chamber liner for advanced rocket engines
- Thermal management systems for nuclear propulsion system



NARloy-Z-40vol.% Diamond Composite Microstructure

Research Team:

NASA Principal Investigator:

Dr. Biliyar N. Bhat/Marshall Space Flight Center (MSFC/EM31)

NASA Co-Investigator:

Dr. Sandra Greene (MSFC/ER32)

External Co-Investigator:

Dr. Jogender Singh/Pennsylvania State University (PSU) – Applied Research Laboratory (ARL)

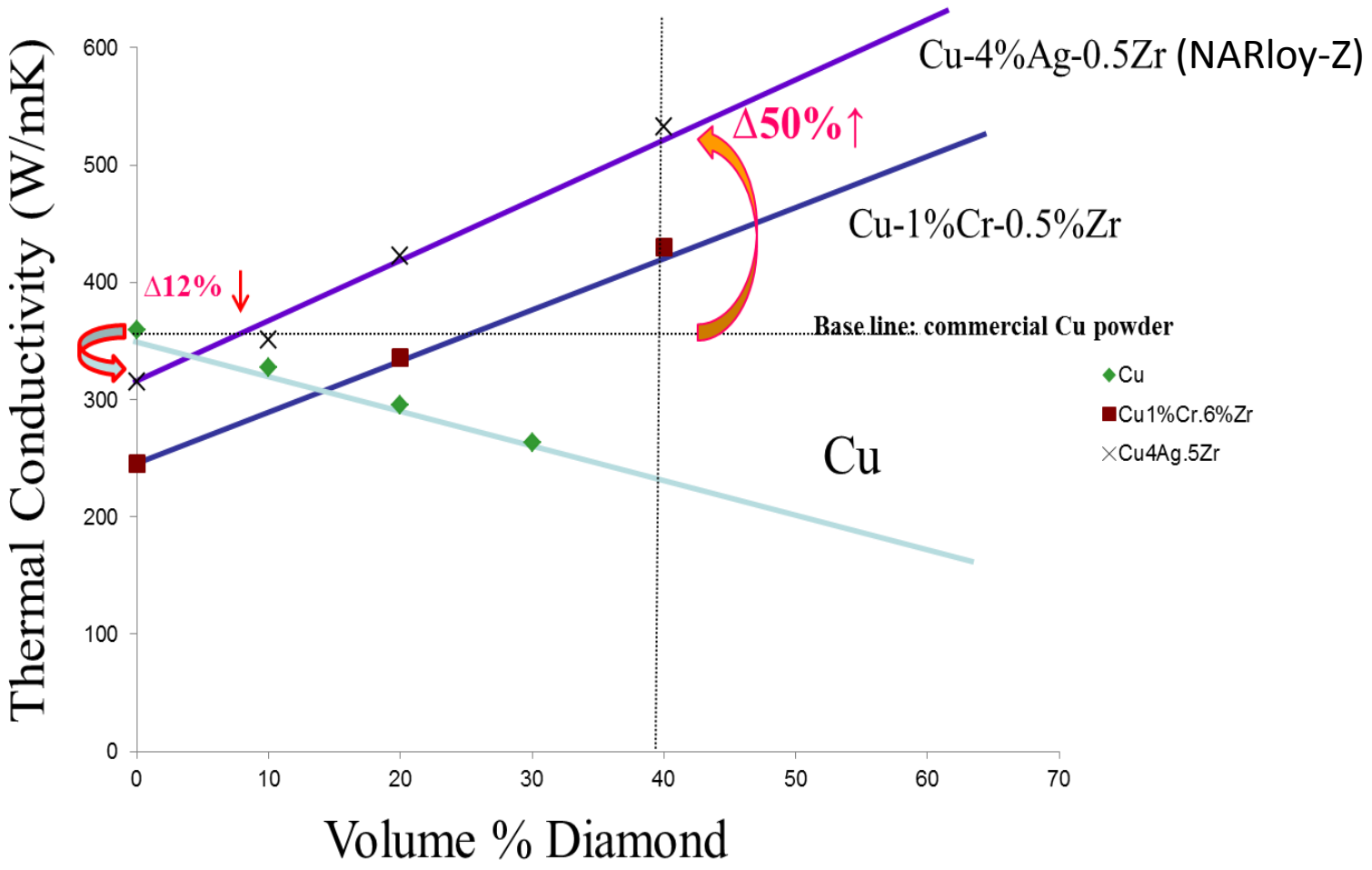
Consultant:

Dr. David Ellis (NASA-GRC)

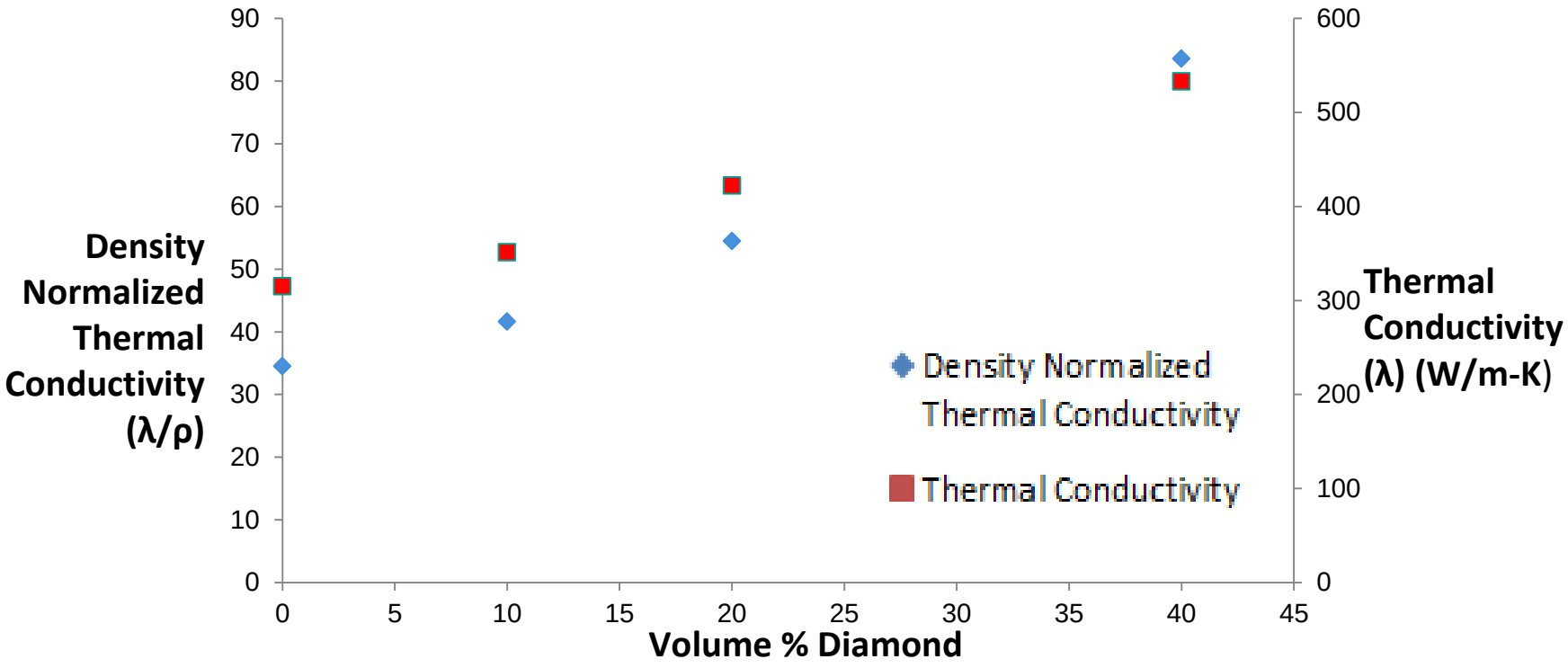
Technical Approach

- Blend NARloy-Z powder with up to 40 volume% of diamond powder to produce NARloy-Z-D composite mixture
- Sinter at elevated temperature using Field Assisted Sintering Technology (FAST) at Pennsylvania State University (PSU)
- Characterize NARloy-Z-D composite
  - Microstructure analysis: SEM, TEM, XPS, EDS
- Develop design properties
  - Thermal conductivity measurements – RT to 1000^{o}F
  - Tensile testing at room and elevated temperatures
- Net shape forming of combustion chamber liner using FAST
- Hot fire testing of combustion chamber liner

Thermal conductivity of NARloy-Z-Diamond Composites

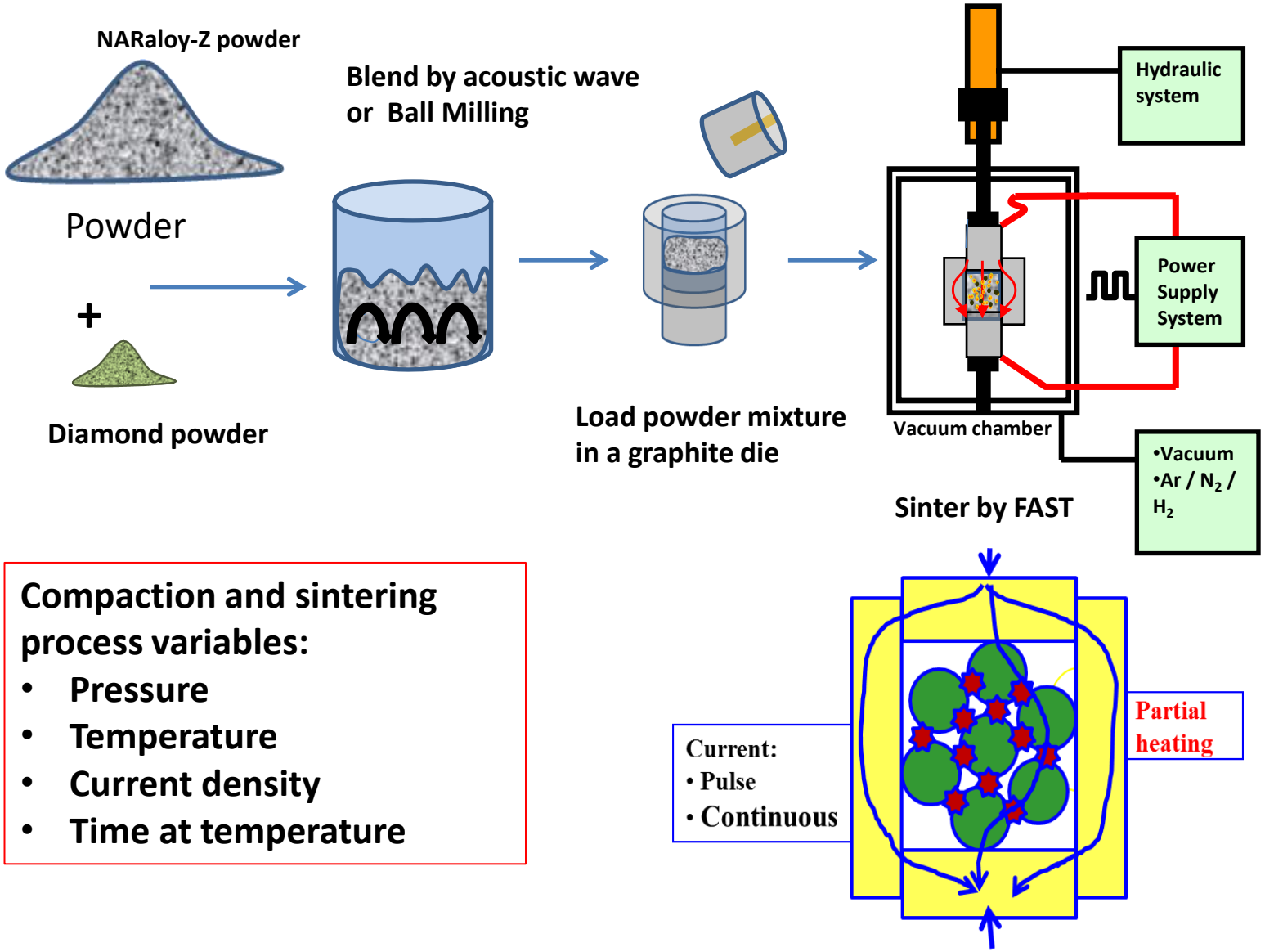


Density Normalized Thermal Conductivity of NARloy-Z-Diamond Composites



140% improvement in density normalized thermal conductivity at 40 Vol.% Diamond

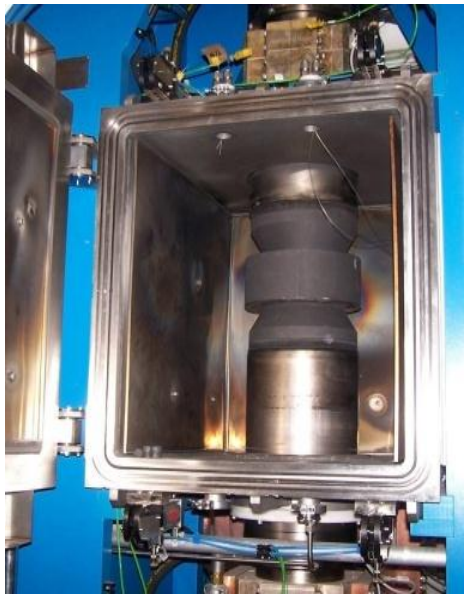
Sequence of powder mixing and sintering by Field Assisted Sintering Technique (FAST)



Compaction and sintering process variables:

- **Pressure**
- **Temperature**
- **Current density**
- **Time at temperature**

Field Assisted Sintering System At Penn State - ARL

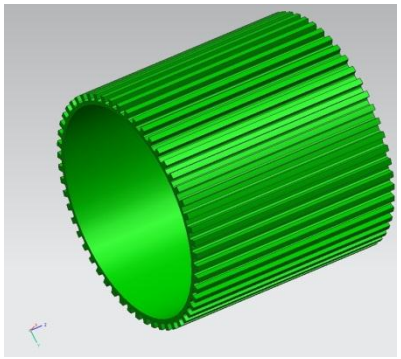


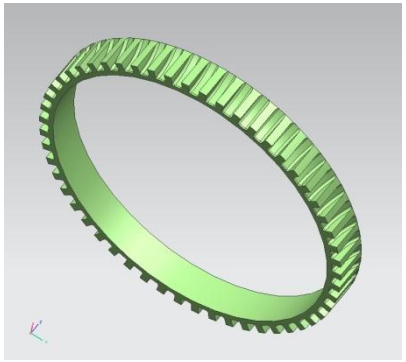
Inside view of furnace chamber

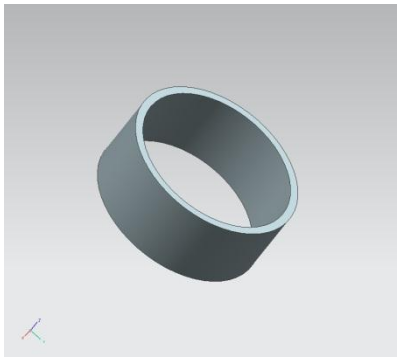
Sintering at high temperature

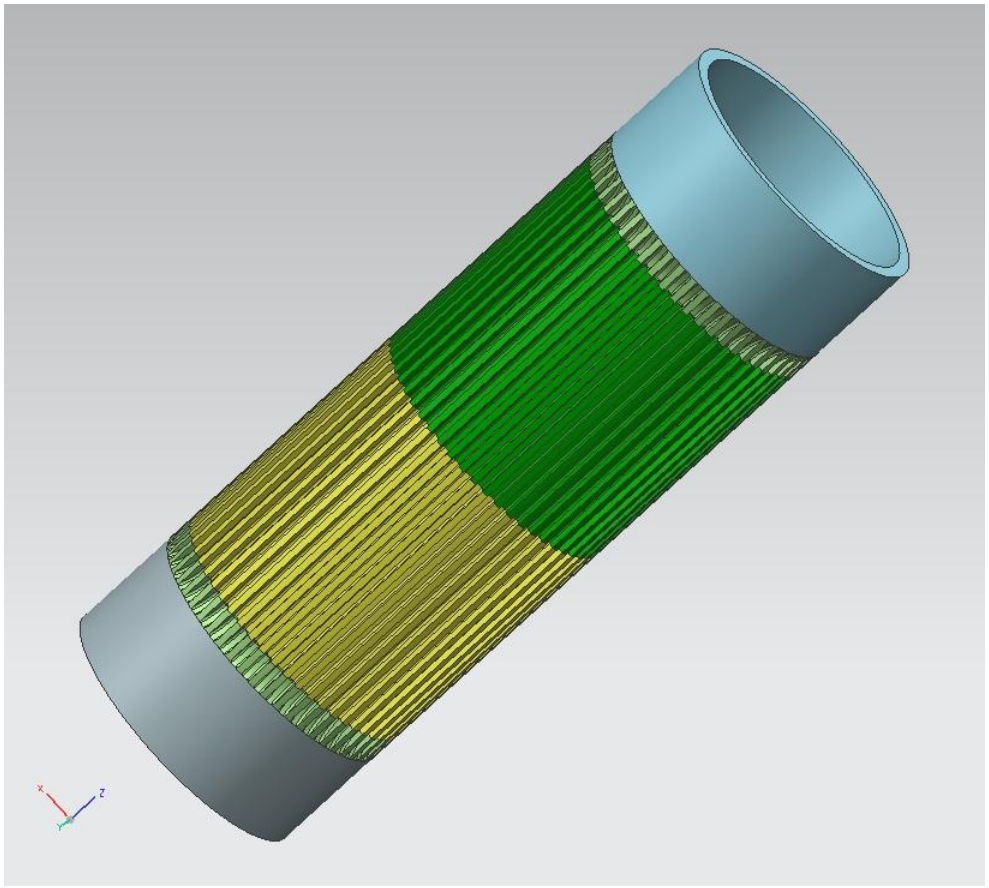
- 250 ton Prototype Large R&D system
- Maximum Diameter: 300 mm
- Pulse current: 0-10KAmps
- Pulse time: 1 to 1000 ms
- Pause duration: 0 to 1000 ms
- Temperature capability: RT to 2400 ^{0}C
- Computerized Process control system

Net Shape Liner Fabrication by FAST









Parts are diffusion bonded to make the liner

Hot fire Testing of NARloy-Z-Diamond Liner

Combustion chamber
liner and test assembly

Hot fire testing at MSFC
Test stand

Test data will be analyzed to determine performance